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November 21, 1991

The Honorable John Conyers, Jr.  
Chairman, Legislation and National  
Security Subcommittee  
Committee on Government Operations  
House of Representatives

Dear Mr. Chairman:

This report on the acquisition strategy for the Army's Longbow Apache modernization program is in response to your request. It includes recommendations to the Secretary of Defense.

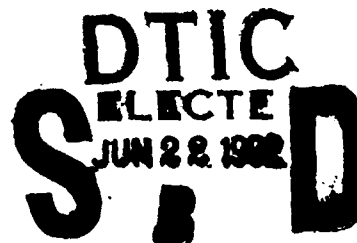
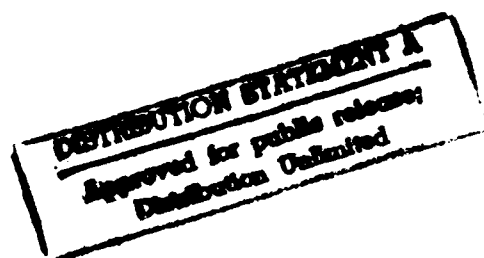
Unless you announce its contents earlier, we plan no further distribution of this report for 30 days from its issue date. At that time, we will send copies to the Chairmen of the Senate and House Committees on Armed Services and on Appropriations and the Senate Committee on Governmental Affairs, the Director of the Office of Management and Budget, and the Secretaries of Defense and the Army. We will also provide copies to others upon request.

Please contact me at (202) 275-4141 if you or your staff have any questions concerning this report. The major contributors to this report are listed in appendix I.

Sincerely yours,



Richard Davis  
Director, Army Issues



# Executive Summary

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## Purpose

The Army plans to spend about \$5.4 billion to modify 227 AH-64 Apache helicopters into Longbow Apache helicopters. The modification program includes the addition of a new radar technology designed to increase the Apache's ability to destroy tanks and other enemy assets. Concerned about the Apache's reliability and logistical support problems and the Army's ability to develop technologically advanced weapon systems, the Chairman of the Legislation and National Security Subcommittee, House Committee on Government Operations, asked GAO to evaluate the Army's acquisition plan for the Longbow Apache to determine whether (1) the plan is designed to identify and correct potential problems before entering full-rate production and (2) the requirements used to evaluate the Longbow Apache will effectively measure its key performance capabilities.

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## Background

The Longbow Apache will incorporate the "Longbow" system—a fire control radar with a radar detector and a Hellfire missile with a radio-frequency seeker. The Army believes the Longbow Apache will provide significant advantages over the Apache, including the ability to automatically classify and prioritize multiple targets and a "fire and forget" missile capability.

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## Results in Brief

As presently planned, the Longbow Apache schedule should allow for the orderly development of technology and provides decision points for assessing progress based on test information and other developments. The challenge for the Army will be to keep the program focused on developing the necessary technology, while carefully weighing funding cuts and the impact of any deviations from planned actions.

Although the Army has expressed its commitment to acquiring a supportable Longbow Apache, weaknesses in the program's requirements may preclude an accurate assessment of the support the helicopter will require when fielded. While indicating that more comprehensive requirements will be used for the Longbow system, the Army plans to use the same narrowly defined requirements to measure the reliability of the integrated aircraft as it used in evaluating the Apache. Doing so will likely yield the same results as it did with the Apache—a technologically enhanced helicopter that is not adequately supported.

Similarly, the Army does not plan to measure required maintenance man-hours that fully reflect the Longbow Apache's expected maintenance needs. The Army plans to measure maintenance man-hours for

the Longbow Apache in the same manner it did for the Apache. In the case of the Apache, its true maintenance needs were masked, and Army maintenance units were understaffed.

## Principal Findings

### Adherence to Acquisition Plan Should Help Avoid Reliability Problems

Several features are included in the Longbow Apache acquisition plan that are aimed at minimizing risk and avoiding some of the problems that occurred on the Apache. These features provide for minimal concurrency between development and production; better-quality and more frequent testing; a low-rate initial production phase; and two more management tools to help assess the program as it progresses.

**Minimal Concurrency:** The Defense Acquisition Board has directed the Army to ensure that the requirements for system performance and reliability are demonstrated before moving to production. As a result, the Army will delay production of the airframe modifications until development of key systems such as the fire control radar and the radio-frequency Hellfire missile are complete. This delay is important because some of the Apache's reliability problems can be traced to Army decisions to rush the development and fielding of the helicopter to meet the perceived threat, even though the technology for key components had not been developed and tested.

**Quality and Frequent Testing:** Frequent testing of the Longbow Apache is planned, and the test program is designed to provide the data necessary at key decision points in the acquisition process. The planned testing for the Longbow Apache is more complete than the operational testing on the Apache. For example, the Army plans to conduct initial operational tests prior to the low-rate production decision using production-representative aircraft and simulated combat situations. Apache operational testing, in contrast, did not involve production-representative aircraft and was not conducted under realistic combat conditions. As a result, the Army did not know the true performance and capability of the Apache at the time it decided to begin production.

**Low-Rate Initial Production:** The Army has scheduled a low-rate initial production phase and plans a decision point after its completion to consider the status of the program and address any problems before committing to full-rate production. In contrast, the Army went from



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development of the Apache directly into full-rate production and missed the opportunity to conduct additional testing that could have identified reliability problems.

Two More Management Tools: The Longbow Apache acquisition plan includes two management tools—a program baseline and the use of exit criteria—that were not used in the Apache program. Established in response to congressional direction, the baseline consists of cost, schedule, and performance parameters. The Longbow Apache program manager is required to notify senior Department of Defense (DOD) and Army officials if one of the parameters is not met. Exit criteria, a still-evolving DOD concept in managing the acquisition of a new weapon system, are specific accomplishments or goals that are determined at key decision points and must be satisfactorily demonstrated before the system can proceed into the next acquisition phase. The Army has established exit criteria for the Longbow Apache's fire control radar and the missile but not for the integrated aircraft.

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### Capabilities of Longbow Apache to Be Evaluated Against Several Outdated and Unreliable Measures

Reliability, availability, and maintainability requirements are key performance measures that (1) influence the design of a weapon system, (2) provide criteria for developing test requirements and assessing test results, and (3) provide a basis for logistic support planning. Without measuring test results against realistic requirements, the Army cannot accurately forecast the performance of a weapon system. For the Longbow Apache, the Army plans to use comprehensive, up-to-date reliability requirements to test the fire control radar and the radio-frequency Hellfire missile; however, the Army plans to evaluate the integrated Longbow aircraft using the same reliability requirements it used for the Apache. The Army did not anticipate the high logistical support demands of the Apache because of the narrowly defined performance requirements and the limited realism of test conditions.

The primary difference between the two sets of requirements is the type of failures measured. For example, using the Apache measure "mean time between mission failure" would include only hardware failures in flight that cause a mission to abort, whereas using the more up-to-date measure "mean time between mission-affecting failure" would include not only hardware failures, but all failures that result in either a mission abort or degradation of a mission-essential function. When the Apache was evaluated against the first measure, it met or nearly met its design requirement, but when compared against the broader measure, its reliability was judged much lower. Other current reliability requirements to

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be omitted from the evaluation of the integrated Longbow aircraft are "mean time between essential maintenance actions" and "mean time between unscheduled maintenance actions."

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### Maintenance Man-Hour Definition Does Not Accurately Portray Need

The Army is excluding important data when calculating the number of man-hours that will be needed to maintain the Longbow Apache for every hour of flight. This "maintenance ratio" is one of the factors the Army uses to determine how many maintenance personnel will be necessary to support a battalion of aircraft. The Longbow Apache has a maintainability goal of 8 hours per flight hour, with a requirement of no more than 13 hours per flight hour. These numbers, however, do not fully account for maintenance needs because the maintenance ratio definition includes only the time spent working on the aircraft. It excludes the time associated with obtaining parts and tools, as well as some time spent diagnosing maintenance problems. Failure to recognize these factors in developing maintenance needs is likely to result in a shortage of personnel to support the Longbow Apache. The Under Secretary of Defense for Acquisition has directed the Army to expand its maintenance data collection system to capture all pertinent activities. The Army is planning to implement this directive, an Army official said.

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### Recommendations

GAO recommends that the Secretary of Defense direct the Secretary of the Army to

- amend the Longbow Apache's requirements document and program baseline to include the current reliability requirements "mean time between mission-affecting failure" and "mean time between essential maintenance actions," and also amend the requirements document to include "mean time between unscheduled maintenance actions" for the integrated aircraft, and
- revise the Army's definition of maintenance man-hours per flight hour to include, as directed by the Under Secretary of Defense for Acquisition, all time related to maintenance work on the aircraft so that an adequate number of maintenance personnel will be provided.

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### Agency Comments

As requested, GAO did not obtain written agency comments on this report. However, GAO discussed its findings with DOD and Army program officials and included their comments where appropriate.

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# Contents

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<b>Executive Summary</b>		2
<hr/>		
<b>Chapter 1</b>		8
<b>Introduction</b>	Longbow System Is Expected to Enhance the Apache's Mission Capabilities	10
	Program Status and Cost	11
	Improved Apache Reliability Is Critical to the Longbow Apache's Success	11
	Objectives, Scope, and Methodology	12
<hr/>		
<b>Chapter 2</b>		14
<b>Effective Army Management and Oversight Are Essential to Longbow Apache Success</b>	Adherence to Acquisition Plan Should Help Avoid Problems That Occurred in the Apache Army's Program Cost Estimates Have Increased	14 20
	Conclusions	21
<hr/>		
<b>Chapter 3</b>		22
<b>Longbow Apache Capabilities to Be Evaluated Against Several Outdated and Unreliable Measures</b>	Requirements Are Important Performance Measures	22
	Meaningful Reliability Requirements Have Not Been Established for the Integrated Longbow Apache Aircraft	23
	Definition of Required Maintenance Does Not Accurately Portray Need	24
	Conclusions	24
	Recommendations	25
<hr/>		
<b>Appendix</b>	Appendix I: Major Contributors to This Report	26
<hr/>		
<b>Figures</b>	Figure 1.1: Longbow Apache Modifications	9
	Figure 2.1: Longbow Apache Program Schedule	15

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## Abbreviations

DOD	Department of Defense
GAO	General Accounting Office
RF	radio frequency





# Introduction

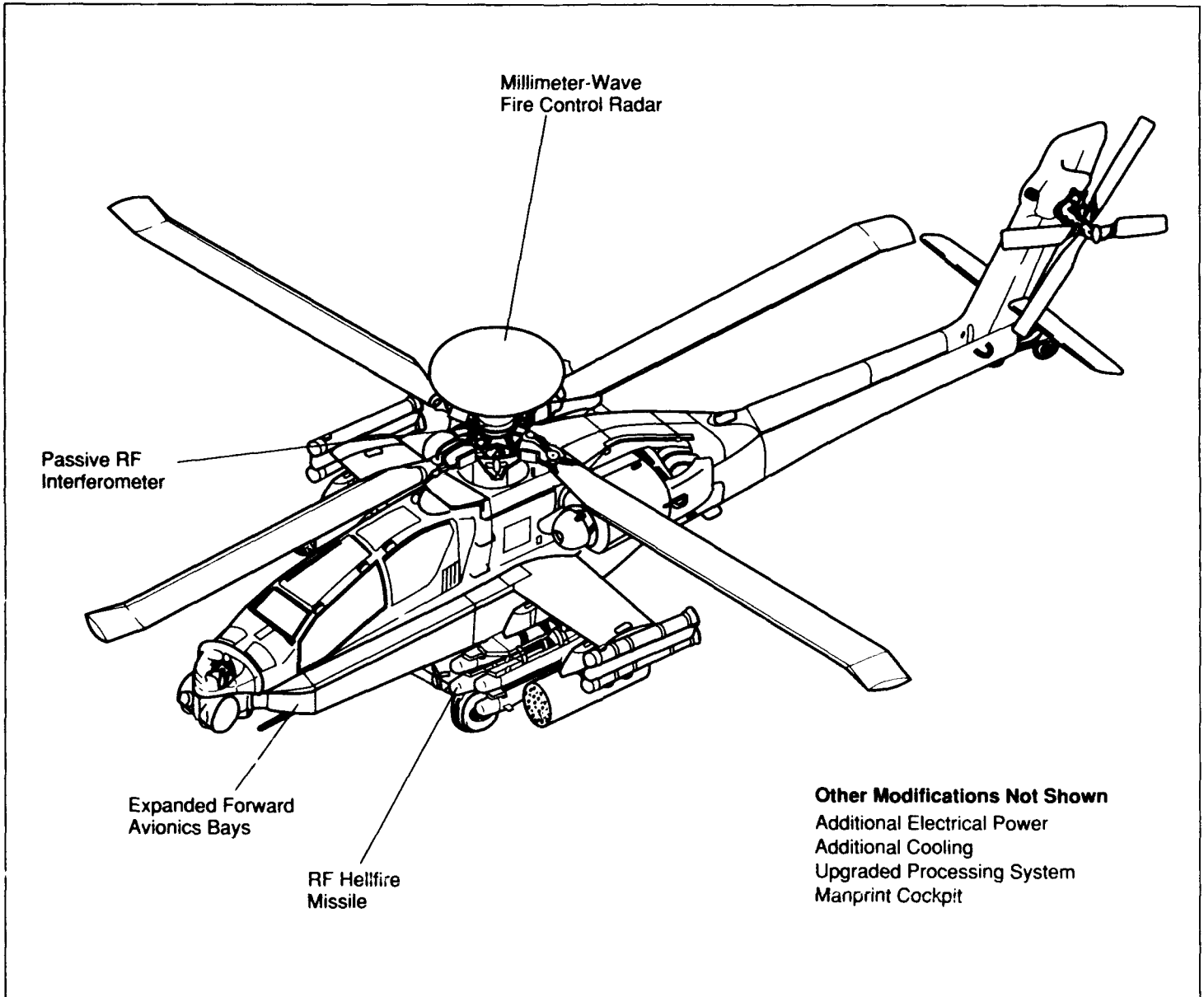
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The Army plans to modify 227 of its AH-64 Apache helicopters to a new configuration called the Longbow Apache. These modifications are expected to enhance the mission capability of the Army's premier attack helicopter to destroy tanks and other enemy assets.

The modification program calls for adding a mast-mounted, millimeter-wave fire control radar, with a passive radio-frequency (RF) interferometer, and an RF Hellfire missile. The millimeter-wave radar detects, classifies, and prioritizes both stationary and moving targets. The RF interferometer detects hostile radar emissions and provides the Longbow Apache information on the direction and identity of the opposing air defense weapon. The RF Hellfire missile is a version of the Hellfire that contains a "seeker" in its nose for locking onto targets. Collectively, the millimeter-wave radar, the RF interferometer, and the RF Hellfire missile are known as the "Longbow" system and could be added to other types of helicopters in the future.

In addition, the Apache airframe will be modified to accommodate the Longbow system. Some of the airframe modifications include (1) a fully integrated cockpit to reduce pilot work load; (2) a vapor cycle cooling system to replace the often troublesome shaft-driven compressor cooling system; (3) expanded forward avionics bays to accommodate Longbow equipment and upgraded generators, batteries, and transformers for additional electric power; (4) an upgraded processing system; and (5) new wiring for the fire control radar. The Longbow Apache helicopter is depicted in figure 1.1.

Figure 1.1: Longbow Apache Modifications



Source: U.S. Army.

## Longbow System Is Expected to Enhance the Apache's Mission Capabilities

The Army believes that the Longbow system will greatly improve the lethality and survivability of the Apache on the battlefield. Further, the Army anticipates that the Longbow Apache will be able to meet the expected threat through the year 2015 more effectively than the current Apache. Specific details of the Longbow Apache's improved performance, such as the time needed for targeting, the number of targets that can be engaged, and the range of the RF Hellfire missile, are classified.

In general, the Longbow Apache is designed to provide the Army with improved capabilities to operate during the day and at night, in adverse weather, and under conditions of poor visibility on the battlefield. These improvements are to be made possible by the Longbow's millimeter-wave fire control radar, which also greatly reduces the time the helicopter is exposed to hostile fire as it acquires and engages targets.

The Longbow Apache is designed to shield itself behind a hill or other type of shelter with only the fire control radar's mast-mounted assembly exposed while scanning the battlefield for targets. The radar is expected to acquire targets in adverse weather because its millimeter waves penetrate obscurants such as clouds, smoke, and fog. After scanning for targets, the fire control radar is to rapidly and automatically classify and prioritize moving and stationary targets. According to a representative of the Army's Directorate for Combat Development, the Longbow Apache will be the first Army aircraft to have the capability of acquiring, classifying, and prioritizing stationary targets.

During the firing of the RF Hellfire missiles, the Longbow Apache is to remain shielded because the pilot can select targets from his display screen and launch several missiles without leaving shelter. Once fired, the RF Hellfire is designed to go to its target without any additional action required of the pilot. This feature is to introduce a "fire-and-forget" capability that current Army helicopters do not have. The RF Hellfire is also expected to engage targets at greater ranges than possible with the Hellfire missile used on the current Apache. Together with the passive radar detector's ability to identify threats by specific type, these improvements are expected to greatly increase the survivability of the Longbow Apache on the battlefield.

Compared with the Apache, the Longbow Apache is to be exposed for shorter and less frequent periods during target acquisition and missile firings. Currently, an Apache pilot must identify targets and decide which one to engage using the aircraft's laser to designate targets for the missiles. The Apache pilot must continue fixing the laser on the

target to guide the missile to it. This process requires the Apache to be exposed to hostile fire for a much longer period than to be required for the Longbow Apache. Also, less time is to be needed between missile firings for the Longbow Apache than for the Apache because the new fire control radar permits firing missiles at a greater rate. Whereas the Longbow Apache is designed to scan the battlefield only once to identify targets, the Apache pilot must repeat the lasing process for each target to be engaged. Further, the Army expects the Longbow Apache to fight in adverse conditions such as fog, clouds, or smoke, which the Apache's laser cannot penetrate.

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## Program Status and Cost

A full-scale development contract for the Longbow Apache was awarded to McDonnell Douglas Helicopter Company on August 30, 1989, and is to run through June 1995. As the prime contractor for the Apache, McDonnell Douglas Helicopter Company is developing the airframe modifications to accommodate the Longbow enhancement and is responsible for the total integration of the airframe, fire control radar, and missile systems. Full-scale development contracts for the RF Hellfire missile and the fire control radar were awarded to a Martin-Marietta and Westinghouse joint venture on December 21, 1990, with both contracts scheduled to run through March 1995. The Army plans to begin production in April 1995, with deliveries scheduled through the year 2000.

The Army's estimated cost for the Longbow Apache program is \$5.4 billion, including \$3 billion to modify 227 of the existing Apaches (a unit cost of \$13.2 million) and \$2.4 billion for the Hellfire missiles. Through this modification program, the Army will modify about 28 percent of the Apache fleet to the Longbow Apache configuration.

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## Improved Apache Reliability Is Critical to the Longbow Apache's Success

In our September 1990 Apache report, Apache Helicopter: Serious Logistical Support Problems Must Be Solved to Realize Combat Potential (GAO/NSIAD-90-294, Sept. 28, 1990), we expressed reservations about the Army's plan to add the Longbow modification to Apache. We recommended that the Army defer production of the Longbow modification until the Army clearly demonstrated that (1) it had overcome the logistical support problems with the current Apache and (2) the Longbow would not exacerbate the Apache's logistical support problems.

The Department of Defense (DOD) and Congress expressed their concern over the Apache reliability problems and have emphasized the need to resolve them before proceeding with the Longbow Apache modification

program. The Defense Acquisition Board, which reviews major defense acquisition programs and recommends whether they should proceed into more advanced stages of development, had already recommended approval for the airframe modification and integration portion of the program when it met in December 1990 to consider the millimeter-wave fire control radar development. At that meeting, the Board recommended approval for the millimeter-wave radar to enter full-scale development. However, the Board concluded that the corrective actions to improve the Apache's reliability should be verified before proceeding with the Longbow Apache modifications.

Congress also raised concerns about the Longbow during consideration of the National Defense Authorization Act for fiscal year 1991. The House and Senate Committees on Armed Services expressed concerns about adding such technologically sophisticated improvements to the Apache in view of its history of maintenance and reliability problems. Congress authorized \$20 million for reliability improvements to the Apache and limited the Army's ability to obligate the authorized Longbow Apache funds. More specifically, the Army was barred from obligating more than half the \$159 million in authorized Longbow funds until the Secretary of the Army developed a comprehensive modernization program for the Apache fleet.

Early in 1991, the Army announced a plan to improve the reliability of the Apache as required by Congress. On March 12, 1991, the Secretary of the Army provided the Chairmen of the Senate and House Armed Services Committees with the congressionally required plan and released the remaining Longbow Apache funds. The Secretary estimated that the planned improvements would be incorporated into the Apache fleet by fiscal year 1995. Our assessment of the Army's efforts to resolve Apache hardware component reliability problems is discussed in a separate report.<sup>1</sup>

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## Objectives, Scope, and Methodology

Concerned about the Apache's reliability and logistical support problems discussed in our September 1990 report and the Army's ability to develop technologically advanced weapon systems, the Chairman of the Legislation and National Security Subcommittee, House Committee on Government Operations, asked us to evaluate the Army's acquisition

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<sup>1</sup> Apache Helicopter: Reliability of Key Components Yet to Be Fully Demonstrated (GAO/NSIAD-92-19, Oct. 3, 1991).

plan for the Longbow Apache. Specifically, our objectives were to determine whether (1) the plan is designed to identify and correct potential problems before entering full-rate production and (2) the requirements against which the Longbow Apache will be evaluated will effectively measure the helicopter's key performance capabilities.

To evaluate the Army's Longbow Apache acquisition plan, we interviewed Army officials and reviewed pertinent records at the Longbow project and Apache program offices; the Army Aviation Systems Command, St. Louis, Missouri; and at the Hellfire Missile project office, U.S. Army Missile Command, Red Stone Arsenal, Alabama. In addition, we interviewed officials of the Directorate for Combat Development, Army Aviation Center, Fort Rucker, Alabama.

We also interviewed representatives of the Office of the Secretary of Defense, as well as the Army's Program Executive Officer for Aviation and his deputy. We reviewed program documents obtained from the program offices and the Directorate for Combat Development. We also reviewed DOD and Army regulations dealing with acquisition, reliability, availability, and maintainability.

We performed our review from October 1990 through October 1991 in accordance with generally accepted government auditing standards.

As you requested, we did not obtain written agency comments on this report. However, we discussed the information in this report with DOD and Army program officials and incorporated their comments as appropriate.

# Effective Army Management and Oversight Are Essential to Longbow Apache Success

The underpinning of the Longbow Apache modification program is different than that of the Apache. The Apache program, according to the Army, was driven by the perceived urgent need to meet a threat. As such, the Army focused on fielding the Apache helicopter as quickly as possible, even though some key components on the Apache had not been fully developed and tested and known support problems had not been resolved.

In contrast, the Longbow Apache modification program is driven by the Army's desire to increase the Apache's mission capability. Accordingly, the Army's plan for acquiring and fielding the Longbow Apache offers the opportunity to avoid many of the problems that occurred in fielding the Apache. Chief among the plan's features is that production of the Longbow Apache is not to begin until the new millimeter-wave radar technology has been demonstrated to work. The plan also includes several changes in response to congressional direction, DOD guidance, and Army efforts to reduce production risks.

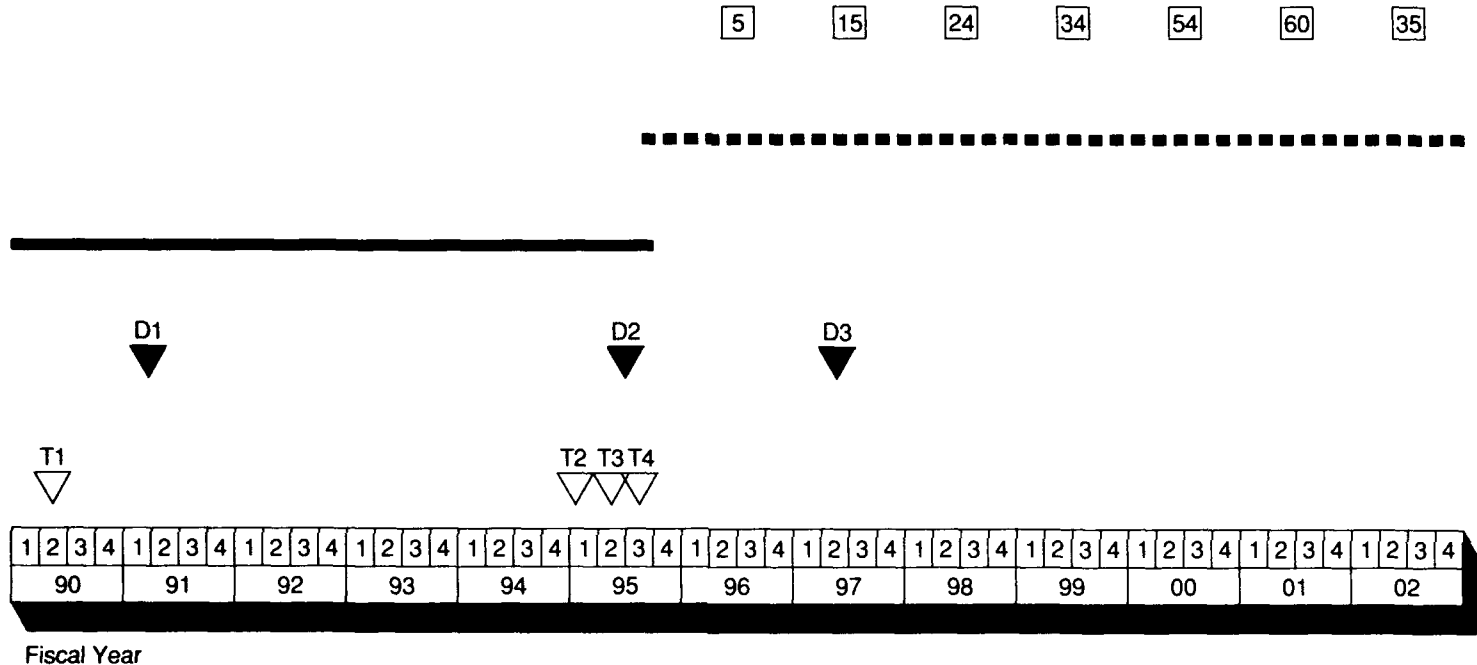
Key to the program's successful implementation, however, is how well the Army manages the risks that arise during development and ensures that the program does not proceed before the millimeter-wave radar technology is proven. Additional costs have occurred with the changes the Army has been directed to make to its acquisition plan to minimize program risks and avoid added costs after production begins. Some of these changes, such as increased testing, have contributed to a \$656 million increase in the Army's overall program cost estimate.

## Adherence to Acquisition Plan Should Help Avoid Problems That Occurred in the Apache

The Longbow Apache acquisition plan includes several steps that are aimed at minimizing risk and avoiding some of the problems that occurred on the Apache. These steps provide for minimal concurrency, better-quality and more frequent testing, a low-rate initial production phase, and two more management tools to help assess the program as it progresses. Figure 2.1 depicts the acquisition schedule for the Longbow Apache.

Chapter 2  
Effective Army Management and Oversight  
Are Essential to Longbow Apache Success

Figure 2.1: Longbow Apache Program Schedule



- ▽ Testing
- ▼ Decision Points
- Development
- Production
- Number of Aircraft Delivered
- T1 Early User Test and Experimentation.
- T2 Force Development Test and Evaluation.
- T3 Initial Operational Test and Evaluation.
- T4 Live-Fire Testing.
- D1 Full-Scale Development Approval.
- D2 Low-Rate Initial Production.
- D3 Full-Rate Production.

Source: U.S. Army

Although the Army's plan for the Apache included many of these same steps, the Army did not implement many of them. The Army's failure to do so has contributed to the problems the Army is experiencing in fielding the Apache helicopter.



## **Minimal Concurrency Planned**

Concurrency is the overlap between the development and production phases of an acquisition program. In other words, some parts or subsystems are being developed, tested, and produced at the same time. When subsystems are especially important to the overall effectiveness of a weapon system or technologically complex, the risks of problems going unresolved increase with concurrent acquisition planning. As shown in figure 2.1, the Army plans a 1-month overlap of live-fire testing with low-rate initial production in fiscal year 1995. The Army's decision to minimize concurrency is intended to ensure that the technology needed for the millimeter-wave radar is demonstrated before a decision to enter production.

According to the Army, the Apache was urgently needed to meet a threat which could not be effectively countered by the Army's existing attack helicopter, the AH-1 Cobra. Although budget cuts and redirections prompted many changes in the Apache program, it was pushed to meet various calendar dates as it progressed, according to the Army. Thus, the Army's efforts were focused on developing the airframe and in fielding the helicopter, even though the technology for some of the key components for the Apache helicopter were not proven. For example, the Army entered production not knowing whether the sophisticated targeting system would work. This system, as a result, has historically been a significant contributor to the aircraft's downtime and it continues to fall short of its reliability requirement.

Another key Apache component that was not fully developed when production began was the 30-millimeter gun. The Army decided to redesign it because of problems that had surfaced in early testing. When the Apache production decision was made, the Army had just begun testing the redesigned gun and did not know whether it would perform as required. The gun remains a source of problems today because it does not meet its reliability and accuracy requirements.

The Army, through the Longbow Apache modification program, plans to enhance the capabilities of the helicopter rather than correct a deficiency in Apache's ability to meet a threat. These enhanced capabilities are dependent on the successful development of the millimeter-wave radar technology. Thus, there is no reason for the Army to begin to produce Longbow Apache before key components such as the millimeter-wave radar are successfully developed.

The Defense Acquisition Board has directed the Army to ensure that required system performance and reliability are demonstrated before

moving to production. In December 1990, the Board approved the Army's request to begin full-scale development of the Longbow Apache but directed changes to its acquisition plan. As a result, the Army will delay production of the airframe modifications until development of the fire control radar, the RF Hellfire missile, and the airframe modifications are complete. In addition, the Army will delay making a low-rate production decision until initial operational testing and evaluation has been completed. Thus, the Army does not plan to move the Longbow Apache program along any faster than the technology will permit, thereby dealing first with the most advanced technology (the millimeter-wave radar).

As presently planned, the Longbow Apache schedule should allow for the orderly development of technology and provide decision points for assessing progress based on test information and other developments. The challenge for the Army will be to keep the Longbow Apache program focused on developing the necessary technology, while carefully weighing funding cuts and the impact of any deviations from planned actions.

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### **Quality and Frequent Testing Is Planned**

The Army tests each new weapon system to assess acquisition risk and verify whether it meets performance specifications and objectives. Testing provides decisionmakers with the data necessary to make choices as a program progresses through the acquisition process. As shown in figure 2.1, the Army's acquisition plan includes frequent tests of the Longbow Apache throughout the acquisition program. However, it is not enough to test a system frequently; tests also must be designed to provide data that accurately reflects the aircraft's true capabilities, and the results of the tests must be used at key decision points in the acquisition process.

The Longbow Apache test program is designed to provide the data necessary for decision making. For example, the Army plans to conduct 900 hours of initial operational test and evaluation prior to the low-rate production decision. The operational test will be conducted using production-representative aircraft, with limited contractor involvement, and will simulate realistic combat situations in day, night, and adverse weather conditions. During these tests, the Army plans to test the supportability of the aircraft and demonstrate that the aircraft's diagnostics work and that the Army's maintenance personnel are able to repair it.

Apache operational testing was not as complete as the planned testing for the Longbow Apache. The Apache operational testing consisted of only about 400 hours and was not conducted under realistic combat conditions. In addition, the Army did not test production-representative Apaches. Rather, the Army operationally tested aircraft which included key subsystems that were to be redesigned after operational testing. As a result, the true performance and reliability of the Apache were not known at the time the Army made the decision to begin production.

The Army also did not test the Apache's logistical support system. For example, during the Apache's operational test the Army relied on contractors to support the Apache. Almost half of all Apache's maintenance actions during operational testing were accomplished by the contractor or with contractor assistance. Because the Army relied on contractors to support and maintain the Apaches, the Army did not have a clear picture of the support system needed to support the fielded aircraft.

In addition, the Army did not operationally test the Apache's on-board fault detection system and ground test station. These systems are key to the Army meeting the high operational availability objectives and were still being developed at the time of the Apache's operational tests.

Because of the supportability problems identified during testing, the Army's Logistic Evaluation Agency, in October 1981, recommended that the Army not begin full-rate production until all supportability deficiencies were corrected. According to the Army, it did not follow the agency's recommendation and decided to enter full-rate production because of the urgent threat.

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### Army Plans Low-Rate Initial Production

The Army has scheduled a low-rate initial production phase in the acquisition plan of the Longbow Apache. The Army, which expects to acquire 28 Longbow Apaches during this phase, plans to award the first contracts for low-rate initial production in April 1995, with a second set of low-rate initial production contracts to follow in November 1995. The Army plans a decision point after completing low-rate initial production before committing to full-rate production. During this period, the Army will operationally test the low-rate initial production aircraft, and the test results should be available before the full-rate production decision. This should provide an opportunity to carefully consider the status of the program and address any problems before proceeding with production.

In contrast, although the Army had planned low-rate initial production following full-scale development for the Apache, the Army instead went directly into full-rate production. Thus, the Army missed the opportunity to conduct additional testing that could have identified problems before beginning full-rate production.

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## **Two More Management Tools for the Longbow Apache**

The Longbow Apache acquisition plan includes two more management tools—a program baseline and the use of exit criteria. The baseline consists of cost, schedule, and performance parameters critical to the success of a system. These parameters include both technical requirements (such as cruise speed, weight, and rate of climb) and operational effectiveness requirements (such as the probability of detecting and classifying targets). Each baseline parameter consists of an objective or desired capability and a threshold or minimum capability.

Congress required the military services to develop a program baseline for all major defense acquisition programs entering full-scale development or production after November 1986 in an effort to increase program stability and improve defense acquisitions. Under the statutory requirement, the Longbow Apache program manager is required to notify the DOD Acquisition Executive, the Secretary of the Army, and the Army Acquisition Executive if a cost, schedule, or performance parameter in the baseline is not met. Whereas the Selected Acquisition Report for the Apache contained information on these parameters, the baseline requirement is an important change because it establishes parameters beyond which the program manager may not trade off cost, schedule, or performance shortfalls against other considerations without approval from the DOD Acquisition Executive.

Exit criteria is a new DOD concept in managing the acquisition of a new weapon system. The criteria are specific accomplishments or goals to be completed for each acquisition phase. These accomplishments or goals must be satisfactorily demonstrated before the system can proceed any further in the process. DOD Instruction 5000.2 defines exit criteria as “gates through which a program must pass during the [acquisition] phase.”

The Army established exit criteria in December 1990 for the fire control radar and the RF Hellfire missile. The exit criteria for the Longbow system’s fire control radar include requirements to demonstrate the probability of detecting and classifying moving targets. The exit criterion for the missile requires it to meet a minimum probability for

achieving a single-shot kill. Although the concept of having exit criteria appears to be sound, the Army has not established exit criteria for important reliability, availability, and maintainability measures for the Longbow Apache. According to a representative of the Office of the Secretary of Defense, the concept of exit criteria is still evolving.

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## Army's Program Cost Estimates Have Increased

The changes the Army has been directed to make to its acquisition plan to minimize program risks and avoid additional costs after production begins have resulted in increases to the estimated cost of the weapon system. The Army's estimated cost of the Longbow Apache program has increased since its August 1990 budget estimate submission of \$4.7 billion for the President's fiscal years 1992-1993 budget. By June 1991, the estimate had increased by \$656 million to \$5.4 billion. The Army's estimate includes the cost to develop and procure 227 modified Apache aircraft, fire control radar units, and 10,896 RF Hellfire missiles.

Most of the cost increase, or about \$560 million of the \$656 million, stems from three major causes: (1) \$236 million to implement DOD requirements to reduce concurrency in the airframe modification program, (2) \$223 million for an additional year needed to produce the missile and fire control radar, and (3) \$101 million for developing the fire control radar.

DOD's actions to reduce concurrency will increase the Longbow Apache's cost about \$236 million in part because the airframe modifications necessary to accommodate Longbow on the Apache are not scheduled to start until fiscal year 1994. Previously, modifications were to start in fiscal year 1992 after the final Apache rolled off the production line. According to the Army, the \$236 million increase resulted from several factors, such as \$100 million from a potential 20-month production gap between the time the final Apache is produced and the beginning of the Longbow Apache airframe modifications; \$86 million to cover inflation that resulted from the program delay; and \$50 million from a 19-month extension of the full-scale development contract for the airframe modifications needed to align its development with the fire control radar and RF Hellfire missile contracts.

The Army's decision to extend the missile and fire control procurement by an additional year adds about \$223 million to the estimated cost. According to the Army, the increase resulted from smaller annual—and therefore less economical—production rates over longer periods. The remaining \$101 million of the \$560 million increase relates to research

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and development costs of the fire control radar. The Army said the related increase resulted from various adjustments in that program, such as a risk reduction plan and a change in the scope of work.

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## Conclusions

The Army has developed Longbow Apache plans that generally follow its acquisition guidance and are designed to reduce risks. While the Apache's plans also were designed to minimize risk, the Army's program execution significantly differed from its plans, thereby considerably increasing risk. Given world events and the existing threat, there appears to be little or no reason to increase risk and move ahead with the Longbow Apache program before the technology has been clearly demonstrated.

# Longbow Apache Capabilities to Be Evaluated Against Several Outdated and Unreliable Measures

The criteria the Army uses to measure Longbow Apache's reliability, availability, and maintainability performance will be critical to determining whether the helicopter can be adequately supported when fielded. Although its overall acquisition plans appear sound, the Army plans to use outdated and narrowly defined requirements—the same as it used for the Apache—to measure the Longbow Apache's reliability, availability, and maintainability. Using these requirements will likely yield the same results as it did with the Apache—a technologically enhanced helicopter that is not adequately supported in the field. Although the Army indicated that more comprehensive, up-to-date requirements measuring reliability would be used to evaluate the Longbow system, it plans to use much more limited pre-1982 requirements to evaluate the reliability of the integrated aircraft. Further, because the Army is not including all relevant maintenance time in its goals for maintaining the Longbow Apache, a shortage of maintenance personnel is likely to result—a problem with the Apache that the Army is trying to resolve by increasing the size of its maintenance units.

## Requirements Are Important Performance Measures

Reliability, availability, and maintainability requirements are key performance measures that influence the design of a weapon system, provide criteria for developing test requirements and assessing test results, and provide a basis for logistic support planning. These requirements are also used to assist Army managers in achieving their objectives for operational readiness, mission success, maintenance man-hour costs, and logistics support costs.

The extensive reliance on reliability, availability, and maintainability requirements makes their realism critical. Without assessing test results against realistic requirements, the Army cannot accurately forecast the performance of a weapon system. Consequently, once deployed, the weapon system may break down more often than anticipated, require more maintenance than expected, and not be able to reliably perform all of its missions. For example, in our September 1990 report on the Apache, we identified the frequent failure of components and the consequent demand for maintenance and for parts as major contributors to the Apache's low fully-mission-capable rates. In addition, the Apache's unexpectedly high logistic support demands were not anticipated based on its test results. The Apache testing did not fully disclose the seriousness of these problems because of narrowly defined reliability, availability, and maintainability performance requirements and the limited realism of test conditions.

## Meaningful Reliability Requirements Have Not Been Established for the Integrated Longbow Apache Aircraft

The Army has included three reliability requirements based on revised regulations in the required operational capabilities document for the fire control radar and the RF Hellfire missile; however, the Army did not include all three measures in the requirements document or the program baseline for the integrated aircraft. Instead, the Army is continuing to use pre-1982 reliability requirements which, when used to evaluate the Apache, did not accurately reflect reliability.

The Army has recognized the limitations of the Apache's requirements. In 1982 it issued regulations mandating the use of more comprehensive requirements for new systems. However, as we reported in September 1990, the Apache's requirements have not been redefined in the terms set forth in the 1982 regulations, and performance is still measured against the limited pre-1982 requirements.

The primary difference between the two sets of reliability requirements is the type of failures measured. One of the pre-1982 measures, "mean time between mission failure," was defined to include only hardware failures in flight that cause a mission to be aborted. In contrast, the updated requirements measure a broader range of failures. For example, one of the new requirements, "mean time between mission-affecting failure," measures all failures, regardless of cause, that result in either a mission abort or degradation of mission-essential function. Another measure, "mean time between essential maintenance actions," records how often mission-essential equipment requires corrective maintenance, regardless of whether an actual mission is being conducted. A third key measure, "mean time between unscheduled maintenance actions," shows all actions taken to correct failures, regardless of cause.

Despite acknowledging the deficiencies of the pre-1982 requirements, the Army believes that using them to evaluate the Longbow Apache is justified because the 1982 regulations "grandfathered" in all existing systems. Thus, because the Apache was in production in 1982, the Army believes that the integrated Longbow Apache aircraft need not be measured against the new requirements.

However, the Army's decision to rely on the grandfather provision in the revised regulations to apply outdated requirements to the integrated aircraft runs contrary to sound acquisition theory and does not reflect the lessons learned from the Apache. As we reported in September 1990, these pre-1982 measures did not always depict the reliability of the aircraft. When the Apache was measured against the pre-1982 requirements, such as mean time between mission failure, it met or nearly met



its design requirements. However, when evaluated against the broader requirements, the Apache's reliability was judged much lower.

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## Definition of Required Maintenance Does Not Accurately Portray Need

The Army continues to exclude important data when calculating the number of man-hours that will be needed to maintain the Longbow Apache for every hour of flight. This "maintenance ratio" is one of the factors the Army uses to determine how many maintenance personnel will be needed to support a battalion of aircraft. The Longbow Apache has a maintainability goal of 8 hours per flight hour, with a requirement of no more than 13 hours per flight hour. These numbers, however, do not show actual maintenance needs because the maintenance ratio definition includes only the time spent working on the aircraft. Excluded is the time for obtaining parts and locating or checking out tools, as well as some of the time spent diagnosing maintenance problems.

The Army measured the maintenance ratio of the Apache using the same definition; as a result, the maintenance ratio did not reflect the helicopter's actual maintenance needs. For example, as we stated in our September 1990 report, "although Army test data has shown that the Apache needs 5 or fewer maintenance man-hours per flight hour, this belies the large maintenance workload experienced by the combat battalions." Further, we stated that Army testing showed that (1) the Apache was well within its goal for maintenance man-hours per flight hour and (2) Apache battalions had too many maintenance personnel. Yet, at the same time, the Army recognized a need for additional maintenance personnel to meet the Apache's work load and was temporarily using civilian contractors to help meet it.

In response to criticism of the Army's maintenance work-load data collection and estimating methodologies during an Army analysis of the Comanche helicopter, the Under Secretary of Defense for Acquisition in July 1991 ordered changes to be made to the system. The Under Secretary directed that the Army's current maintenance work-load data collection system be expanded Army-wide to capture the direct, indirect, and nonproductive activities.

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## Conclusions

Although the Army has established more comprehensive reliability requirements for the Longbow portion of the Longbow Apache, it did not establish similar requirements based on current regulations for the Longbow Apache as an integrated aircraft. As a result, the Army will continue to evaluate the Longbow Apache against the same narrow

requirements that were used to evaluate the Apache and proved to be misleading.

The Longbow Apache maintenance burden may, like that of the Apache, be severely understated and therefore lead to overly optimistic maintenance requirements. Until its definition of maintenance man-hours is revised to include all related maintenance time, the Army will not have an accurate picture of the time needed to perform maintenance or the number of maintenance personnel that will be needed to support the aircraft. The Under Secretary of Defense for Acquisition shares our concern about the Army's maintenance measure. If the Army continues using this flawed measure, it may not be prepared to keep pace with the Longbow Apache's maintenance work load because it will not have enough people to do the maintenance work. This would eventually have a negative impact on the Longbow Apache's availability rates, as it did with the Apache.

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## Recommendations

We recommend that the Secretary of Defense direct the Secretary of the Army to

- amend the Longbow Apache's requirements document and program baseline to include the current reliability requirements "mean time between mission-affecting failure" and "mean time between essential maintenance actions," and also amend the requirements document to include "mean time between unscheduled maintenance actions," and
- revise the Army's definition of maintenance man-hours per flight hour to include, as directed by the Under Secretary of Defense for Acquisition, all time related to maintenance work on the aircraft so that an adequate number of maintenance personnel will be provided.

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